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EFFECT OF WEIRS AT THE CANAL HEAD-WORKS ON THE DISTRIBUTION OF *CATLA CATLA* (HAMILTON), IN THE PUNJAB

BY

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(*with a map*).

I. INTRODUCTION.

Catla catla is a valuable food fish attaining to six feet or more in length, and is an inhabitant of fresh water. It was at one time found in great abundance in the rivers and streams of the plains of the Punjab. Its presence in the hill-streams has never been reported. Unlike *Labeo rohita* (Hamilton) and *Cirrhina mrigala* (Hamilton), *Catla catla* (Hamilton) is now, however, not so widely distributed in the Punjab. Consequently, an investigation into the causes of the rarity of *Catla catla* in the Punjab was undertaken.

II. LOCATION OF WEIRS IN THE PUNJAB RIVERS.

Apart from the Jamuna and the Indus which form respectively the south-eastern and the north-western boundaries of the province, the Punjab is endowed with five big rivers and a network of canals. The five rivers, Sutlej, Beas, Ravi, Chenab and Jhelum take their origin from the hills on the north-east and flow through the plains of the Punjab towards the south-west, falling ultimately into the Indus, beyond the boundary of the Punjab.

The waters of all the above-mentioned rivers except the Beas, are utilized for irrigation purposes by building weirs across the rivers for the canal head-works. The Beas joins river Sutlej at 'Hari-ke-pattan', about thirty miles on the east of Husainiwala (Ferozepore) weir.

Two weirs have been built across river Jhelum, one at Mangla, where the river leaves the hills and enters the plains. The Upper Jhelum Canal takes its origin from Mangla Head-works. The second weir for the Lower Jhelum Canal at Rasul is about eighty miles from Mangla weir. All the water of the Jhelum is diverted into these canals, and the river below the Rasul weir remains dry for the

greater part of the year. Except during a few months in the summer (monsoon), the Upper and the Lower Jhelum canals work alternately, as there is not enough water in the river for both the canals during winter.

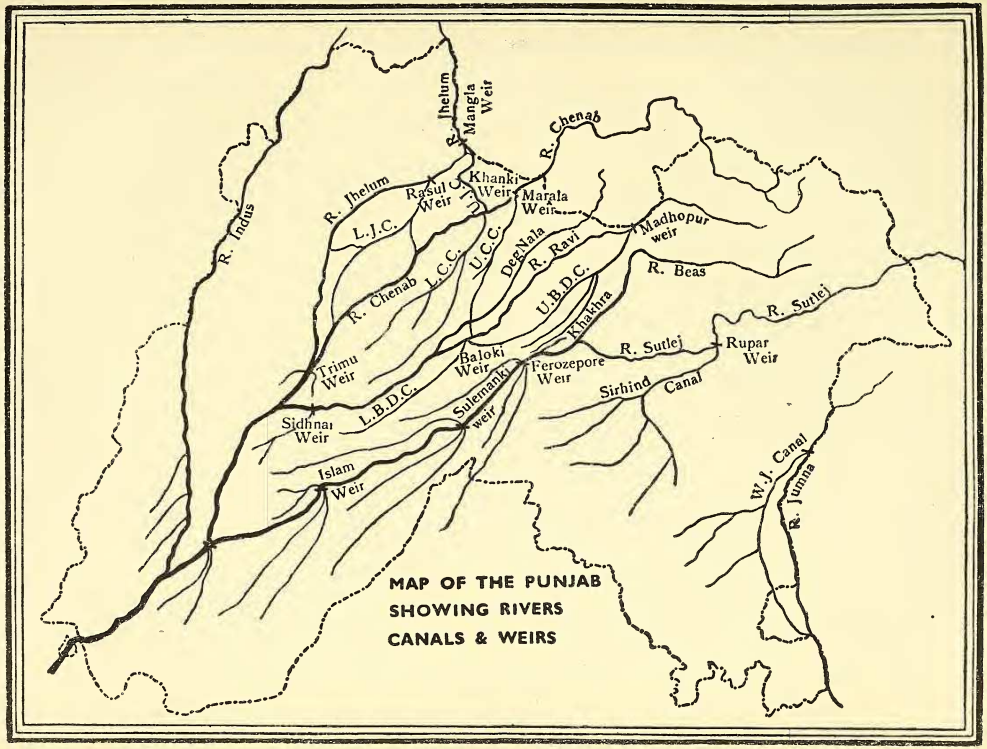
The Chenab has three weirs, one at Marala, the second at Khanki, and the third at Trimu. The Upper Chenab Canal takes its origin from the Marala Head-works, where the Chenab enters the plains. The Lower Chenab Canal takes its origin from Khanki Canal Head-works. The water in the Chenab below the Marala weir is not sufficient for the Lower Chenab Canal during the winter months. It is, therefore, supplemented by the supply from the Upper Jhelum Canal. During winter, no water is allowed to pass into the river below the Khanki weir, and one can easily walk across the river during these months when its bed is either dry or the water is hardly a few inches deep. The author, himself, crossed the river during the month of January, 1929, about forty miles below the Khanki weir, where the water was only ankle-deep. The canal which takes its origin at Trimu weir gets its full supply of water during the period when there is excess of water in rivers Chenab and Jhelum which join a few miles above the Trimu weir. During winter the supply into the canal is hardly sufficient to meet the minimum demands of the people whose lands are irrigated by this water. Not a drop of water is allowed to pass at the Trimu weir into the river during the greater part of the year.

Like Chenab, river Ravi has three weirs, one at Madhopur, second at Balloki, and the third Sidhnai weir near Ram Chontra. From Madhopur to a distance of about hundred miles, river Ravi contains very little water during the winter months. The supply of water is supplemented by the water from the Upper Chenab Canal which is diverted into the Lower Bari Doab Canal at Balloki weir. No water passes below Balloki weir for the greater part of the year. River Ravi, like the Jhelum and the Chenab, remains almost dry for the greater part of the year, and whatever fish is left in the pools which are formed in the beds of these rivers, is caught by the fishermen during the winter months.

The Sutlej enters the plains at Rupar, where the head-works for the Sirhind canal is built. The conditions of the Sutlej below the Rupar weir upto 'Hari-ke-pattan' where the Beas pours its supply of water into the Sutlej, are similar to those of the Ravi before the Upper Chenab Canal falls into it. During winter the water in river Sutlej above the Rupar weir is not sufficient even for the Sirhind Canal. As in river Ravi, the pools in the bed of river Sutlej from Rupar to 'Hari-ke-pattan' are netted by the fishermen, and no fish is left in this tract of the river. Below 'Hari-ke-pattan', river Sutlej gets all the water from the Beas, and the three weirs of the Sutlej Valley Project, Husainiwala (Ferozepore), Suleimanki, and Islam at Palla, divert the water into the canals which take their origin from the above weirs. Below the Islam weir, the river is absolutely dry.

III. Survey of the Waters.

In order to trace the distribution of *Catla catla*, a survey of these waters was conducted. Quite a large number of fishing places along


R. Jhelum
Mangla Weir
R. Chenab
R. Jhelum
Rasul Weir
Khanki Weir
Marala Weir
R. Indus
L.J.C.
U.C.C.
Deg Nala
R. Ravi
Madhopur weir
R. Chenab
L.C.C.
U.B.D.C.
R. Beas
R. Sutlej
Khakhra
Baloki Weir
R. Sutlej
Rupar Weir
Trimu Weir
Ferozepore Weir
Sirhind Canal
L.B.D.C.
Sulemanki weir
Sidhnai Weir
Islam Weir
W.J. Canal
R. Jumna
MAP OF THE PUNJAB
SHOWING RIVERS
CANALS & WEIRS

the rivers were visited by the author during the course of the last few years. River Jhelum contains mahseer, *Barbus* (*Tor*) *putitora*, to a considerable extent, even during the journey to a great distance in the plains, and *Catla catla* is not reported to exist even upto the Rasul weir. Although river Jhelum is said to enter the plains at Mangla, still we find small hills running parallel to the river even beyond the Rasul weir in Jhelum District.

Catla catla was at one time caught in considerable numbers by the fishermen from river Chenab and Palkhu, its important tributary. But for the past few years, neither adult *Catla* nor its fry have been found in Palkhu and the pools round about it, where it once spawned in large numbers. The deep pools and the important fishing places on Palkhu, which at one time gave shelter to adult *Catla*, have now been silted up.

The big pools formed in the back-waters of river Ravi, were at one time the home of *Catla catla*. But, during the course of the last few years, *Catla catla* seems to have become extinct in river Ravi. In a pool about ten miles from Lahore in river Ravi, several maunds of big adult *Catla catla* alone were netted, some years ago. But *Catla catla* has been caught in very small numbers for the last few years above Balloki weir. The author got certain pools netted below the Sidhnai weir near Katalpur, where a few specimens of *Catla catla* were found. But these pools remain cut off from the main stream due to the paucity of water below this weir. *Catla catla* has not been able to get its hold for the last few years anywhere in river Ravi, due most probably, to scarcity of water in a great stretch of the river between the weirs, and due to lack of opportunity for spawning. Nikki Deg, a tributary of river Ravi, where fry of *Catla catla* was at one time caught in considerable numbers, now remains dry for the greater part of the year. *Catla catla* has not been traced for the last few years along with *Labeo rohita* and *Cirrhina mrigala* fry in the pools where they are stranded during the monsoon floods. *Catla* fry is not found in Sakki, another important tributary of the Ravi in Amritsar District, where fry of *Cirrhina mrigala* and *Labeo rohita* are met with in great abundance.

No weir has been built across river Beas, hence it is always full of water. Big adult *Catla* has been caught in this river throughout its length and breadth. Even above Naushera ferry, which is hardly ten to twelve miles from the place where the Beas enters the plains, *Catla catla* weighing about thirty seers was netted. River Beas merges its identity into the Sutlej at ' Hari-ke-pattan '. The distance from ' Hari-ke-pattan ' to Mirthal where river Beas enters the plains, upto which *Catla catla* can survive, is about 120 miles. Abundance of *Catla catla* is found in river Sutlej from ' Hari-ke-pattan ' downwards, although very little *Catla* is found in the pools of river Sutlej from ' Hari-ke-pattan ' to Rupar. Buddha Nala, a tributary of river Sutlej near Ludhiana, which at one time had not only deep pools but also good fishing places in its bed, has, like Palkhu, been deprived of the deep pools and fishing places where *Catla catla* could take shelter.

There are certain big dhands, above ' Hari-ke-pattan ' in Ludhiana and Ferozepore districts, cut off from river Sutlej, where big *Catla* is caught in quite a large number, but they are few and far between.

They, no doubt, serve as sanctuaries for *Catla catla*, but they cannot supplement the supply of *Catla catla* into the river, unless very heavy floods which come after a decade or so, connect these dhands with the rivers. Below 'Hari-ke-pattan', *Catla catla* is found in great abundance in river Sutlej, its tributaries and other pools, dhands and back-waters which are flooded when the river swells before the rains or during the monsoon floods. During the visit of the author to different places along river Sutlej from Islam weir to 'Hari-ke-pattan', there was no place where *Catla catla* was not found in large numbers. There is a big dhand enclosed by the 'bunds' of the head-works, on the right bank of river Sutlej, a little above the Islam weir, which serves as a pocket to store large quantity of water for the use of the head-works authorities. The reservoir contains big pools where *Catla catla* and other big fishes take shelter. The backwaters of river Sutlej at Tibbi Lal Begh and Machhisinghwala in Montgomery District, serve as sanctuaries for the fry of *Catla catla*. The fields lying in between the Sutlej and these dhands serve as spawning grounds for *Catla catla*. At one time the dhands at Machhisinghwala contained large numbers of *Catla catla* and its fry, but they are being filled up.

During the course of the summer months (May and June), large numbers of adult *Catla catla* are seen in the pools just below the weirs at Suleimanki and Husainiwala (Ferozepore), but they are helpless and do not venture to pass through the fish-ladders to come into the lakes formed above the weirs.

Khakhra, a tributary of river Sutlej in Lahore District, has a big dhand containing large number of carp fry. Fry of *Catla catla* formed 60 per cent of the fish-population of this dhand when netting was tried in October, 1944, and it still dominates the fauna of this dhand. Khakhra is a small stream, and this dhand in Khakhra is said to be a part of the old bed of river Beas when rivers Beas and Sutlej flowed parallel for a considerable distance in Lahore and Montgomery districts. The other dhands and pools on either side of river Sutlej below Khakhra also contain quite a large number of fry of *Catla catla*.

IV. Discussion.

From the survey of the waters carried out, it is evident that *Catla catla* is in abundance in the waters of river Sutlej and its tributaries, viz. Beas, Khakhra and other pools below 'Hari-ke-pattan', connected with it during floods. The lakes above Husainiwala (Ferozepore), Suleimanki and Islam weirs serve as sanctuaries for *Catla catla*. The Sutlej, thus, always contains enough of water from 'Hari-ke-pattan' to Islam weir, and *Catla catla* gets an opportunity to reach its spawning grounds in the Sutlej and the Beas above the Ferozepore weir, as the Beas contains enough water throughout the year.

Catla catla and its fry is found in great abundance in the pools which are flooded during July and August above the Husainiwala (Ferozepore) weir. Fry of *Catla catla* has also been found in large numbers in the areas which are flooded above Islam and Suleimanki weirs.

Catla catla, on the other hand, has not been found in appreciable numbers at any place in rivers Ravi and Chenab and their tributaries

like Palkhu, Deg and Sakki, where at one time they were found in large numbers.

We are, therefore, led to the conclusion that the weirs at the canal head-works in the Punjab rivers, enumerated above, seem to have interfered seriously with the distribution of fishes in general, and *Catla catla* in particular, due to the following reasons:

1. Most of the water at the weirs, e.g. Rupar, Madhopur, Balloki, Khanki, etc., is diverted into the canals, and large stretches of the rivers below the weirs either remain dry or contain very small amount of water. *Catla catla* is a big fish as compared to other fishes, and requires deeper and larger volume of water for its abode and at the time of its spawning. It, therefore, cannot live in greater stretches of the rivers which contain very little amount of water, except in the pools formed in their beds here and there, from which all the fish is netted out during the winter months.

2. The migration of *Catla catla* is seriously interfered with by the weirs which obstruct its passage from the rivers to the spawning grounds higher up above the weirs. Hamid Khan (1924) mentions that most of the Cyprinidae, such as Rohu (*Labeo rohita*), Morakha (*Cirrhina mrigala*), Theila (*Catla catla*), as well as some Siluroids, namely, Bachwa (*Pseudeutropius garua*), Khagga (*Rita rita*) and others, ascend the rivers during the monsoon rains in search of suitable spawning grounds. Hamid Khan (1940) says that for the propagation of all game and food fishes of the Punjab, proper facilities are needed to enable them to ascend the rivers so as to reach such waters as will suit them to lay their spawn. He has further stated that with the development of irrigation projects in the Punjab, dams or weirs have been constructed in the form of masonry works at the head-works of the canals for the purpose of deflecting water into the canals. The weirs run across the entire width of the river obstructing both the upward and the downward passage of fish.

3. Day (1873) recommended that every irrigation weir spanning a river should have a practicable fish-pass in it. Dunsford (1911) drew the attention of the Punjab Government to the erection of fish-passes and suggested certain principles for guidance. But although fish-ladders have been constructed across the weirs at the canal head-works, yet *Catla catla* does not seem to pass the weirs through the fish-ladders, due most probably to certain defects in the working of the fish-ladders. Bayer (1908) says that the underlying principle in the construction of fish-ways is the retardation of the current velocity of a waterfall so as to enable fish to surmount it.

4. In most cases the pools at the bottom of the fish-ladders, where the fish would naturally collect before ascending the river, are either too small and are full of silt and other accumulations and deposits, or are not connected with the main current of the river below the weir. According to Dunsford (1911), the pass (fish-ladder) must be situated where it will be self-advertising, i.e. it must form a current impinging into a certain place below the obstacle so strongly that it becomes the chief or predominant current of the stream, where the fish will be led to that point for attempting the ascent.

5. Due to its timid and shy nature *Catla catla* does not seem to make use of the defective fish-ladders constructed across the weirs.

6. The fish, especially *Catla catla*, which enters the canals at the

canal head-works, is considered lost. In the absence of any fish passages from the canals into the rivers, *Catla catla* cannot come back into the rivers in most cases due to the strong current and steep falls of water into the canals at their origin.

In other countries, e.g. U.S.A., great care has been taken to facilitate the migration of fish and to reduce the harmful effects of the weirs on their productivity. But although fish-passages have been constructed in the weirs at the canal head-works in the Punjab, yet they either do not work properly and remain out of use, or they are not built suitably and are not wide enough to allow big varieties of fish, like *Catla catla*, to pass up and down the river.

V. Summary.

The Punjab, as its name signifies, has five big rivers which irrigate the parched soil of the province. There are twelve weirs in four out of the five rivers, the Beas being an exception, from where eighteen canals take their origin. The weirs at the canal head-works divert, in almost all the cases, most of the water from the rivers into the canals. Due to the weirs built at different places, large stretches of the river-beds remain dry or contain very little water during the major part of the year.

Catla catla, which is a fresh-water fish and grows to a big size, was at one time found throughout the plains of the Punjab. Due to its build and size, it needs deeper water for its abode and spawning. Its movements before and during the spawning season are interfered with by the weirs built at the canal head-works. The fish-ladders, which have been built as passages for the fish to cross the weirs, are not suitably built, and do not work properly. *Catla catla* does not seem to make use of the fish-ladders, due perhaps to its size and its shy and timid nature. The fish which enters the canals along with the water of the rivers at the weirs, is considered lost, there being no passages from the canals to the rivers, as the fish cannot go back into the rivers due to the absence of fish-passages at the heads of the canals.

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INCIDENCE OF FISH MORTALITY ON THE WEST COAST[1]

BY

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'Widespread fish-mortality is a well-known phenomenon on the Malabar and South Kanara coasts: its recurrence yearly along certain stretches of the coast line is regular, though its intensity varies within wide limits' (Hornell, 1917). This unusual incidence of mortality has been attributed to the suffocative influence of certain forms of Marine Euglenoids that suddenly burst in particular regions. Since the initial report of Mr. Hornell on this subject was published in 1917, no attention was paid to this problem, although its importance is self-evident.

A detailed investigation by us in 1944 and 1946 has thrown some more light on this subject. The present communication serves to add further to Mr. Hornell's observations (1917).

There is a regular uniformity in the incidence of fish mortality on the West Coast, since the phenomenon usually occurs during the North-East monsoon. On the 3rd of November 1944, a large number of *Sillage sihamma*, *Gobius* spp., *Caranx* spp., *Ambassis dayi*, prawns and *Pristipom* spp., were seen struggling for life in the water near the shore regions off Calicut. *Ambassis* was found to be much affected. The fishermen of the locality made a big haul of these fishes struggling in the initial stages of death. As the day aged on, the phenomenon continued with greater intensity and shoals of these fishes died, decayed and were washed ashore in heaps, emitting a foul odour all around. The water in which the casualty occurred was muddy, and it was thought that the movement of mud banks had caused this wholesale death in the inshore regions. Mr. C. F. Sims, Port Officer, Calicut, in a communication to the Biological Station, wrote on this question of mud banks: 'The mud bank appears to extend from the shore to nearly four cables seawards all along the coast. The absence of the usual shore waves and swells over this particular area, indicates the presence of the mud deposit there, below the still waters. It is perhaps due to under currents shifting mud from the bed of the open sea towards the shore, or from subterranean rivers of mud forced to the surface, through the sea bed, due to the action of the sea. This silt is generally oily and alien to the sea sand and is not conducive to fish life. The formation of this mud bank usually occurs during the North-East monsoon.' No more information could perhaps be obtained at that time.

The incident recurred next year, although not near the inshore regions but far out in the open sea. Mr. Sidney Schofield, Master of S.S. *Wing Sang*, in a communication to the Station, wrote that some 10 miles off Cochin beyond Lat. 10°27′ N., Long. 76° East, the ship ran into a shoal of dead tunny 'all handsome, fresh and healthy specimens', obviously only recently dead perhaps within the previous two or three hours. The mortality extended to 10 miles. Each carcass was separated by .0°27′ or 150 yards from its neighbour and on the assumption that they covered a circle of 10 miles in diameter, Mr. Schofield calculated their number to be between 20,000 and 40,000. The ship is said to have steamed through this area for an hour at 12½ knots speed. Eight days later and about 48 miles south of this area of catastrophe, Mr. Schofield again witnessed some hundreds of dead fish along a tide-rip. The head, guts and gills were all missing, but the fresh barbs of the dorsal fins still remained and manifested the fact that they were all tunny, all except a very large one at some considerable distance away which was probably a shark. Many birds were leisurely feeding on them and the smaller fish under the surface were having a good time. Presumably the fish seen that day were remnants of those witnessed by Mr. Schofield eight days earlier and carried southwards by a current. The Port Officer, Cochin, writing on this incident commented that every year masses of dead fish float in the harbour area, producing a stench. 'These float in on the flood tide. The cause has always been attributed to the presence of mud banks along this coast which when stirred up, probably as a result of the South-West monsoon, give off

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[1] Published with the kind permission of the Director of Industries and Commerce, Madras.

gas or liquid, which poisons the fish over a period of two or three days annually in August.' The cause was now also attributed to mud banks.

Hornell (1917) also observed a series of similar incidents. There have been of course, differences and fluctuations in the periods of occurrence, sites in which casualty took place, and the species affected. But certain inferences can be drawn from these observations which may be summarised as follows:—

(1) That the casualty is caused by localisation of poisonous water called *Kedunir* and *Karanir* (Shore water). (*Sennir* (Red water) that Hornell has clubbed with this is not poisonous and is caused by Noctiluca swarms.)

(2) That this phenomenon occurs soon after the South-West monsoon, or just after the outbreak of North-East monsoon—more commonly the latter.

(3) The phenomenon lasts for a short period only, since perhaps the effect of *Kedunir* and *Karanir* is soon counteracted by the flowing in of good water.

The popular beliefs and English versions of this incidence of piscine mortality have been dealt with in detail by Hornell (1917). The phenomenon recurred twice in the course of the last year.

The first incident occurred in and around a rock (*Pambankallu*), half a mile to the west of Pudiappa shore in the sea and two miles to the north of West Hill Biological Station. On the 20th of September 1946, the staff of the Biological Station in the course of collecting spat of *Mytilus edulis*, fell upon a big haul of a variety of fish in different stages of asphyxiation, coma and death. The species affected were *Plotosus arab*, *Serranus panlherinus*, *Palinurus* spp., *Scylla serrata*, *Neptunus* spp., *Plagusia marmorata* and *Cynoglossus brevirostris*. Big specimens of *Plagusia*, *Cynoglossus* and *Plotosus arab* were swimming in a state of coma, struggling hard for their life, evidently due to lack of oxygen; 'many keeping their mouths above water were collected by mere hand'. As soon as the incident was reported to us, we repaired to the place immediately. But unfortunately, by this time the phenomenon had been eclipsed by the flowing in of fresh sea water, and so we could collect no more data. The gills of the dead fish were red and blood-shot. The stomachs were empty in all cases.

On the 31st of October 1946, a similar incident occurred near West Hill Biological Station. Heaps of fish were washed ashore by the mild swells of the sea, and many more were found floating dead in the mild breakers very near the shore. The incident was noticed in the afternoon. The fish were in a high state of putrefaction and the whole region stank in a nauseating manner. Evidently the creatures had died some 10 or 12 hours before, at some other place. This was confirmed by local enquiries; fishermen told us that the incident had occurred just past midnight on the 30th, about a mile away from us. When we noticed the incident, there was a very slight drift to the south and the water had begun to flow in. The area affected was about two miles long and about half a mile wide.

The water in which the fish were found floating was brownish, resembling hay decoction in colour. The following physical conditions were noted:—

Time.	*Surf. Temp.*	*Sp. gravity.*	*pH.*
3 p.m.	33·5°C.	1020·0	9·2
4 p.m.	33·1°C.	1020·3	9·1
5 p.m.	32·4°C.	1020·6	9·0
6 p.m.	31·6°C.	1020·8	8·8

The oxygen content of the water at 3 p.m. was 3/100000, and at 6 p.m. 6/100000. There was a slow but moderately big current flowing from north to south, and it was evidently carrying fresh sea water into this area. The phenomenon passed off at about twilight. The catalogue of the species affected, which is a long one, consisted of the following:—

Anodontostoma chacunda (Buch. and Ham.).
Ololithes ruber (Schn.).
Johnius carutta (Bloch).
Sillago sihama (Forskal).
Cynoglossus semifasciatus (Day).
Cynoglossus spp. (specific characters beyond recognition),

Muraena spp. (beyond recognition).
Rastrelliger kanagurta. (Rupp.) (one specimen).
Therapon jarbua (Forskal).
Caranx melamphygus Cuv. and Val.
Etroplus suratensis (Bloch). (one specimen).
Loligo spp.
Engraulis spp.
Ambassis dayi.
Arius spp.
Plotosus spp.

The presence of *Etroplus suratensis*, a brackish-water form, in this list is interesting. The only plausible explanation is, that this incident occurred first, perhaps, in the early hours of the 31st, at the mouth of one of the various brackish-water canals that enjoin the sea a few miles to the north of the West Hill Station.

The plankton collected from this area and centrifuged showed myriads of Euglenoids which were brownish-yellow with plenty of chloroplasts. The flagellum which Hornell (1917) described was not visible; nor could we find the red eye-spot. However, the rapid peculiar settling of these organisms to the bottom of the water to form a 'semi-quiescent' light-yellowish jelly was witnessed by us also.

This flagellate was described in detail by Hornell and Naidu (1924) who observed also the existence of the jelly-like matrix with many of these organisms embedded in it in the sea bottom of the West Coast. 'The range of this organism seawards is great. It appears to assume its motile stage only so long as the water is in gentle agitation. In calm weather this is quite quiescent ready to throw off new swarms of the motile form when the proper excitation occurs' (Hornell and Naidu).

The outbreak of the monsoon is usually attended by an abundant supply of nutrient materials in the inshore waters of West Coast. The rough seas prevailing at this time of the year render observation of the phenomenon difficult. With the gradual return to normal weather, the sea becomes calm. Currents begin to change and the mud banks to shift. This movement of mud-banks induces the slight agitation required to throw off the motile forms of the Euglenoid from the gelatinous matrix. The first indication of the movement of the mud-banks is the throwing ashore of a large number of Cavernularia and Hippa. This agitation of mud casts up a lot of oily material and causes a mild, but efficient, mixing of the different strata of water. 'The sun after the heavy rains becomes a power in the Malabar sky'. The Euglenoids thrown off by the gelatinous matrix are immersed in a medium surcharged with all the necessary nutrient material for their development and multiplication. Photo synthesis occurs and results in the production of myriads of active and motile Euglenoids. They use up the oxygen in the water medium at night, when the water is almost completely deoxygenated. Simultaneously, the mud suspension settles. Rapid decay of the multitudinous Euglenoids sets in creating and producing 'nauseous and evil smelling' decomposition products. The death of all living forms in the area is thus effected by two causes: asphyxiation due to lack of oxygen and toxic effects of dead and decaying Euglenoids.

The course of events leading up to the mortality of fish may be summarised as follows:—

1. With the change in current very soon after the monsoons, the mud-banks begin to move and this gives the required agitation for the throwing off of the quiescent Euglenoids from the jelly-like matrix at the bottom.

2. Fine sunlight and sufficient nutrient materials in the sea water end in a sudden outburst of these Euglenoids, which at night use up almost all the oxygen in the surrounding medium, thereby causing asphyxiation to the fishes in the locality.

3. With the settling of the mud in the area, the sea becomes calm, and with the powerful sunlight acting on it, causes a rapid decay of the dead organisms, thus creating deleterious and toxic effects to the piscine fauna.

4. Good sea water flowing into the region restores normal conditions.

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THE EARLY STAGES OF INDIAN LEPIDOPTERA

BY

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PART XX

(*Continued from Vol.* 47 p. 219)

RHOPALOCERA

PAPILIONIDAE

Papilio polytes L., *romulus* Cr.

Sevastopulo, *Journ., Bomb. Nat. Hist. Soc.*, xlvi, 575. 1947.

A rare form of pupa, which I have only seen formed in captivity, is green, the wing cases lightly mottled with fawn and with a darker green, triangular, central mark. The keel on the mesothorax filled in with fawn, and with the subdorsal triangular mark on the anterior portion of the abdomen fawn instead of the usual yellow-green. The subdorsal tubercles and a ring round the spiracles fawn. The cephalic horns, the sides of the thorax and the abdomen mottled lightly with fawn.

Described from a pupa bred in Calcutta in November 1946.

Zetides doson Fldr., *eleius* Fruhs.

Sevastopulo, *Journ., Bomb. Nat. Hist. Soc.*, xliv, 415. 1944.

Ovum—Very pale green, spherical, the base flattened. Fairly large. Laid singly on the underside of a young leaf of the foodplant.

1st instar—Head dark olive brown. Body jet black, the anal somite whitish. A double subdorsal and a lateral series of short tubercles from 2nd to 12th somite bearing long, forked, black bristles, 2nd and 3rd somites with an additional dorsal pair. 1st somite with a subdorsal, 2nd and 3rd somites with an additional tubercle between the subdorsal and lateral series, anal somite with an outspread pair of whitish dorsal tubercles, all the preceding rather larger than the others and armed with medium length bristles. The thoracic somites swollen, the body tapering towards the rear.

2nd instar—Similar, but only the large tubercles on the thoracic and anal somites present. Colour bronzy, clad with very short black pubescence, giving a velvety appearance.

Described from a larva bred from ova found in Calcutta in June 1946.

PIERIDAE

Cepora (*Huphina*) *nerissa* F., *phryne* F. (*evagete* Cr.)

Sevastopulo, *Journ., Bomb. Nat. Hist. Soc.*, xl, 394. 1938.

Talbot, *Fauna Brit. Ind.*, Butterflies, i (2nd edit.), 363, pl. 2, figs. 7, 8. 1939.

My above quoted description was a comparative one for publication in a London magazine. The following is a more complete description.

Ovum—Typical Pierid shape, the upper end terminating in a ring of teeth, sides longitudinally ribbed. Colour white when first laid, later becoming orange. Laid singly on a leaf or shoot of the food-plant, above or below.

Young larva—Head brownish green. Body yellowish green, rather oily-looking. Under a lens clothed with brownish pubescence.

Full grown larva—Head and body rich leaf green, densely sprinkled with minute white points, those on the body placed in transverse lines, and clad with short white pubescence. A fringe of slightly longer whitish far sublaterally. Venter greenish white with a green median stripe. Legs and prolegs greenish white.

Pupa typically Pierid in shape, the cephalic snout rugose and slightly down-curved, the thorax keeled, 3rd abdominal somite expanded laterally and ending in a spine above the wing case. Suspended by a girdle and tail pad of white silk. Colour usually bluish green, but may be yellower green or, rarely, brownish, the wing cases and venter paler. The cephalic snout, a dorsal patch on the pro-thorax, the thoracic keel, a subdorsal patch on the 2nd and the whole of the dorsal area of the 3rd abdominal somite to the tip of the spine pale buff. The spine itself and the extreme edge of the thoracic keel black. Traces of a buff dorsal line on the abdomen and a yellow lateral line. A subdorsal series of black specks.

Described from a full fed larva found in Calcutta 11. vi. 46, pupated 13. vi. 46 and a male emerged 22. vi. 46.

Talbot, quoting Bell, states that the head in the first two instars is black. I did not observe this.

Anapheis aurota F., *aurota* (*Belenois mesentina* Cr.)

Moore, *Cat. Lep. Mus. E. I. Co.*, i, 72, pl. 12, figs. 9, 9a. 1857.

Bell, Aitken and Davidson, *Journ., Bomb. Nat. Hist. Soc.*, x, 575. 1897.

Moore, *Lep. Ind.*, vi, 158, pl. 527, fig. 1. 1904.

Bingham, *Fauna Brit. Ind.*, Butterflies, ii, 157. 1907.

Bell, *Journ., Bomb. Nat. Hist. Soc.*, xxi, 1153. 1912.

Talbot, *Fauna Brit. Ind.*, Butterflies, i (2nd edit.), 381, pl. 2, figs. 5, 6. 1939.

Ovum—Of typical Pierid shape, upright, longitudinally ribbed, the top surrounded by a ring of teeth. Laid in fairly large batches. Colour almost white when first laid, later becoming a pale creamy yellow.

1st instar—Head black. Body oily, yellowish-green. Clothed with forked, colourless hairs.

Full grown larva—Head black dotted with yellow, each dot emitting a white bristle, the clypeus filled in with greenish and outlined by a broad, green, inverted V. Body with a broad, shiny, yellow-green, dorsal stripe with the central portion rather bluer green, a grey-black lateral stripe and a yellow green sublateral. 1st somite with a yellow dorsal collar. 2nd and 3rd somites with four raised yellow points dorsally, 4th to 11th somites with an anterior

inner and a posterior outer pair of raised yellow points. The lateral stripe, which encroaches slightly onto the dorsal area on the 12th somite and which joins on the 13th leaving a small V-shaped yellow-green dorsal spot, minutely yellow-speckled and with a median series of raised yellow points. A sub-lateral series of raised yellow points. Anal plate black. Venter, legs and prolegs yellow green, the legs and prolegs with black shanks. The dorsum of the 1st somite anteriorly and the sublateral area clothed with short white hairs, the rest of the body pubescent.

In the 2nd and 3rd instars the head is black and the larvae are gregarious. The yellow speckling of the head and the V mark develop in the 4th instar, when the larvae scatter.

Typical Pierid pupa in shape, head produced into a short central point, thorax slightly keeled, 3rd abdominal somite with a large spine over the edge of the wing case. Suspended by a girdle and tail pad of white silk. Colour pale whitish-, greenish-, or pinkish-grey, the cephalic snout, the posterior slope of the thoracic keel and the abdominal spine outlined with black. The thorax streaked and spotted with blackish, abdominal somites with two dorsal and a subdorsal series of minute black specks. Thoracic somites each with six, abdominal with four, raised yellow spots. A whitish lateral line, below which the abdomen is paler. Wing cases paler, streaked along the inner margin with blackish and with short blackish streaks along the veins starting from black specks on the outer margin.

Food-plant—*Capparis horrida.*

Described from larvae bred from ova found in Calcutta, one of which pupated 20. v. 46 and a male emerged 25. v. 46.

The pupa is described as being dimorphic, a green form being produced among leaves. Talbot's figure shews a green pupa with yellow spots, although the text states that the green form has them black.

I found the larvae very delicate in the pre-pupational stage, many of them bleeding profusely and dying after they had hung up.

GRYPOCERA

Celaenorrhinae

Tagiades japetus Cr. (*atticus* Swinh. *nec* F.), *khasiana* Moore.

Ovum—Pale crimson. Almost spherical, the base flattened. Under a lens with a few, slightly raised ribs running from micropyle to base, and covered with pale buff hairs, presumably from the anal tuft of the female. Laid singly on the upperside of a leaf of the food-plant.

Newly hatched larva—Head large, honey-coloured, slightly indented above. Body dull green, with a broad dorso-lateral crimson stripe.

Half grown larva—Head black, heart-shaped, fairly large. Body greenish yellow with a dorso-lateral crimson stripe.

Full grown larva—Head dark mahogany, broadly heart-shaped, rather large. Body greyish green, minutely speckled with white, a

dark, pulsating, dorsal stripe. Legs and prolegs pale grey-green. Anal flap flat and rounded, yellowish. 1st somite constricted forming a neck.

The young larva lives in a cell formed of a roughly circular piece cut from the edge of the leaf, turned over and secured by a few silken threads. The circular piece is not entirely severed, a small attachment being left. The habit is lost in older larvae, at any rate in captivity.

Pupa between two spun-together leaves, and supported by a girdle and tail pad. Unangled, head truncate, square, with a short, central, forward-pointing, tuberculate process. General ground colour pale bone, minutely speckled with brown so that there is a pale brown appearance. Head and pro-thorax suffused with brown, a diffused brown stripe on the meso-thorax and with the thoracic sutures brown. Paired blackish dorsal spots on the 2nd, 6th and 7th abdominal somites, which may be obsolescent. Underside of the head with a chalky-white diamond containing a dark brown M. Wing cases with two, roughly diamond-shaped chalky-white blotches, the anterior small, the posterior larger. The 3rd abdominal somite with a triangular, chalky-white, lateral mark just above the wing case. An interrupted subdorsal brown stripe on the abdominal somites, indistinctly edged below with chalky-white. 6th to 8th abdominal somites with indistinct chalky-white lateral patches. Two lateral black spots on the 4th abdominal somite against the wing case. 4th to 6th abdominal somites with a sublateral series of brown streaks. Cremaster down-curved. The chalky-white markings composed of an external waxy powder.

Described from larvae bred from ova found in Calcutta, one of which pupated 13. xi. 46 and a male emerged 22. xi. 46.

HETEROCERA

Lymantriidae

Perina nuda F.

Sevastopulo, *Journ., Bomb. Nat. Hist. Soc.*, xl, 405. 1938.

Ovum—Spherical, flattened above, the micropylar area depressed. Colour reddish purple, a silvery ring round the micropylar area. Laid in small, neat, regular batches. Laid 31. x. 46. Hatched 6. xi. 46.

1st instar—Head chestnut. Body yellowish, 4th and 5th somites with the dorsum black, 7th to 10th with a double dorsal grey stripe, which joins on the 10th somite. 1st somite with subdorsal tubercles. Clothed with long, plumose, colourless hairs.

2nd instar—Head black. Body grey, the 1st, 4th and 5th somites black dorsally. A subdorsal black stripe on the 2nd and 3rd and on the 7th to 10th somites, where it is joined by a black transverse bar. Subdorsal tubercles on the 1st somite and a transverse band on the 11th orange. Clad with long, grey, simple hairs.

3rd instar—Similar but generally darker. The tubercles on the 1st somite black and the orange on the 11th reduced and more crimson.

4th instar—Body blackish, the dorsal area of the 2nd and 3rd somites blue-grey, a white dorsal line on the 7th to 9th somites. Otherwise similar to previous instar.

5th instar—Similar.

6th (penultimate) instar—Similar to preceding, but the head dark brownish grey. The subdorsal area on the 7th to 9th somites with the hair-bearing warts ringed with blue.

Described from larvae bred from ova obtained from a female caught in Calcutta.

SPHINGIDAE

Deilephila nerii L.

Sevastopulo, *Journ., Bomb. Nat. Hist. Soc.*, xliv, 420. 1944.

Re-reading Bell and Scott's description of the larva of this species (*Fauna Brit. Ind.*, Moths, v, 270. 1937), I have noticed an error. The 3rd instar larva is said to have the horn particoloured, the basal half green, the apical half thin and translucent, the two parts separated by a black ring, whilst the 4th instar larva is described as being similar in all respects to the full grown one. This is incorrect, it is the 4th instar larva that has the horn particoloured, the horn of the 3rd instar larva being black with the extreme base yellow and of normal shape.

NOCTUIDAE

Leucania irregularis Wlk.

Ovum—Very pale yellow with slight opalescen reflections. Almost spherical, the base flattened, but usually flattened above as well through the pressure of the grass blade within which it is laid. Laid in small batches in a folded blade of grass and covered with a transparent cement. Unsculptured. Laid 22. xi. 46. Hatched 28. xi. 46.

1st instar—Head dark honey colour. Body grey, turning green after feeding. A few short colourless hairs. Moves as a semi-looper.

2nd instar—Head dark honey colour. Body brown, turning green after feeding, with eight longitudinal purple lines.

3rd instar—Similar to preceding.

4th instar—Head pale brown, a darker line on each side of the clypeus. Body with the dorsum olive green with a pale dorsal line and two more indistinct pale lines on either side, the olive green area bounded by a pale subdorsal line. Below the subdorsal line there is a brownish-green line, its edges darker, and bordered below by another pale line, below which is a narrow purple-brown lateral line edged below in turn by a pale line, a yellow-green line and a pale line.

5th instar—Head pale brown, a darker line from outside the clypeus to the vertex. Body green, the colour and pattern formed by minute dots on a pale ground. A double dark green dorsal line, a narrow dark green subdorsal stripe with an indistinct dark line between it and the dorsal line. A white line below the subdorsal line, followed by a pale olive stripe with darker edges, a very narrow white line and a dark green stripe with a pale central line. A